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(54) **CATALYST FOR SYNERGISTIC CONTROL OF OXYNITRIDE AND MERCURY AND METHOD FOR PREPARING THE SAME**

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(57) **ABSTRACT**

Disclosed are a catalyst for synergistic control of oxynitride and mercury and a method for preparing the same. The catalyst includes the following components by mass percentage: a carrier: TiO<sub>2</sub> 72%-98.6%, active components: V<sub>2</sub>O<sub>5</sub> 0.1%-5%, WO<sub>3</sub> 1%-10%, Cr<sub>2</sub>O<sub>3</sub> 0.1%-5% and Nb<sub>2</sub>O<sub>5</sub> 0.1%-5%, and a co-catalyst of 0.1%-3%. The present invention can be used for reducing the oxynitrides in a flue gas, meanwhile oxidizing zero-valent mercury into bivalent mercury and then controlling the reactions, has relatively high denitration performance and also has high mercury oxidation performance; compared with current commercial SCR catalysts, the mercury oxidation rate of the catalyst is improved to a great extent, which can adapt to the requirements for mercury removal in China's coal-fired power plants, the conversion rate of SO<sub>2</sub>/SO<sub>3</sub> is relatively low, and the catalyst has a better anti-poisoning ability, and is a new catalyst with a low cost and high performance.

**5 Claims, No Drawings**

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## 1

**CATALYST FOR SYNERGISTIC CONTROL  
OF OXYNITRIDE AND MERCURY AND  
METHOD FOR PREPARING THE SAME**

This is a U.S. national stage application of PCT Appli-  
cation No. PCT/CN2013/089075 under 35 U.S.C. 371, filed  
Dec. 11, 2013 in Chinese, which is hereby incorporated by  
reference.

## FIELD OF THE INVENTION

The present invention relates to a catalyst production  
technology field, especially a catalyst for synergistic control  
of oxynitride and mercury and a method for preparing the  
same.

## BACKGROUND OF THE INVENTION

Mercury, as a kind of toxic heavy metal, may injure  
nervous system, brain tissue and liver tissue after entering  
into the human body, and can accumulate in living creature  
and transfer around the world along with the food chain, thus  
having great harms. About one third of mercury discharged  
into the atmosphere comes from the mixed combustion  
process of coal or coal and wastes and the environmental  
protection pressure in China is tremendous because of the  
huge consumption of coal.

Considering that most power plants are now equipped  
with selective catalytic reduction (SCR) denitration devices  
and wet desulfurization systems, there is no need to add  
independent mercury removal equipment by oxidizing zero-  
valent mercury into bivalent mercury and then removing  
mercury in desulfurization system, which will help power  
plants to save pollutant control cost and have greater appli-  
cation prospect. However, low-chlorine coal is mainly used  
in power plants in China with lower HCl concentration in  
flue gas, while the current commercial SCR catalyst has a  
low mercury oxidation efficiency, which restricts the control  
of mercury in coal-fired power plants especially under the  
condition of low chlorine.

A Chinese patent CN102764655A discloses a new mer-  
cury removal catalyst which is prepared via pillared mont-  
morillonite by mixing  $TO_x$  (T refers to Cu, Fe, V) and  $RO_y$   
(R refers to La, Ce) with titanium dioxide. Such catalyst has  
high mercury removal efficiency, a certain anti-poisoning  
ability, no denitration capability and a complicated prepara-  
tion process, and thus is not applicable for industrial  
application.

## SUMMARY OF THE INVENTION

The present invention aims at solving such problems as  
low zero-valent mercury oxidation efficiency, narrow tem-  
perature window, poor anti-poisoning ability and other  
shortages of the current commercial SCR catalyst, and  
providing a catalyst for synergistic control of oxynitride and  
mercury to reduce the oxynitrides in a flue gas, meanwhile  
oxidize zero-valent mercury into bivalent mercury and then  
control the reactions, so as to have relatively high denitration  
performance and also has high mercury oxidation perfor-  
mance. Compared with prior art commercial SCR catalysts,  
the mercury oxidation rate of the catalyst of the present  
invention improved greatly, which can satisfy the require-  
ments for mercury removal in China's coal-fired power  
plants, the conversion rate of  $SO_2/SO_3$  is relatively low, and  
the catalyst has a better anti-poisoning ability, and is a new  
catalyst with a low cost and high performance.

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The present invention also discloses a method for prepar-  
ing the catalyst which is simple, practicable and applicable  
for industrial production.

Technical solution for solving problem in the present  
invention is as follows:

A catalyst for synergistic control of oxynitride and mercury  
and the catalyst comprises the following components by  
mass percentage: a carrier:  $TiO_2$  72-98.6%,  
active components:  $V_2O_5$  0.1-5%,  $WO_3$  1-10%,  $Cr_2O_3$  0.1-  
5% and  $Nb_2O_5$  0.1-5%,  
and a co-catalyst of 0.1-3%.

It is preferred that the co-catalyst is selected from  $CuO$ ,  
 $Fe_2O_3$  and  $MoO_3$ .

It is preferred that the  $TiO_2$  is nanoscale anatase  $TiO_2$  with  
particle size of less than 30 nm and the preferred particle  
size is less than 20 nm.

A method for preparing the catalyst for synergistic control of  
oxynitride and mercury, comprising the step of:

1) drying  $TiO_2$  and using it as a carrier;  
2) stirring ammonium metavanadate and ammonium  
metatungstate under  $50^\circ C$ - $70^\circ C$ . to dissolve them in an  
oxalic acid or tartaric acid solution to obtain a solution A  
with pH value less than 2;

stirring chromic nitrate under  $10$ - $50^\circ C$ . to dissolve in  
deionized water or tartaric acid to obtain a solution B;  
stirring niobium oxalate under  $50$ - $70^\circ C$ . to dissolve in  
deionized water or tartaric acid to obtain a solution C;

3) stirring cupric nitrate under  $10$ - $50^\circ C$ . to dissolve in  
deionized water or tartaric acid to obtain a solution D;  
or stirring ferric nitrate under  $10$ - $50^\circ C$ . to dissolve in  
deionized water or tartaric acid to obtain a solution E;  
or stirring ammonium molybdate under  $10$ - $50^\circ C$ . to  
dissolve in deionized water or tartaric acid to obtain a  
solution F;

4) mixing the solution A, solution B and solution C with  
one of the solution D, solution E and solution F to obtain an  
impregnating solution, immersing the carrier from step 1)  
into the impregnating solution, stirring evenly for ultrasound  
concussion, evaporating and stirring with water bath for  
10-60 minutes, drying in the oven and then calcining under  
 $400^\circ C$ - $550^\circ C$ . for 3-5 h to obtain a catalyst for synergistic  
control of oxynitride and mercury.

Concentration of oxalic acid and tartaric acid in the  
present invention is preferred to be 1 -10wt % and 1 -20wt  
% respectively.

It is preferred that the drying in step 1) is drying under  $105^\circ C$ - $120^\circ C$ . for 12 hours-24 hours.

It is preferred that the ultrasound concussion time in step 4)  
is 10-60 minutes.

It is preferred that the water bath temperature in step 4) is  
 $70$ - $90^\circ C$ .

It is preferred that the drying condition in oven in step 4) is  
drying under  $105$ - $120^\circ C$ . for 12-24 hours.

During research, the inventor unexpectedly found that the  
synergistic effect of  $Cr_2O_3$  and  $Nb_2O_5$  can accelerate mer-  
cury oxidation to a much greater extent and improve deni-  
tration activity with minor impact on  $SO_2/SO_3$  conversion  
rate. The addition of  $CuO$ ,  $FeO$  or  $MoO_3$  can improve the  
stability and poison resistance and expand the reaction  
temperature window of the catalyst.

Based on long-term engagement in flue gas denitration,  
mercury removal and synergetic control of multiple pollut-  
ants, the inventor developed a catalyst for synergistic control  
of oxynitride and mercury so that the catalyst has higher  
denitration performance and higher mercury oxidation per-  
formance. Compared with current commercial SCR cata-  
lysts, the mercury oxidation rate of the catalyst is improved

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to a great extent, which can adapt to the requirements for mercury removal in China's coal-fired power plants, the conversion rate of  $\text{SO}_2/\text{SO}_3$  is relatively low, and the catalyst has a better anti-poisoning ability, and is a new catalyst with a low cost and high performance.

Beneficial effects of the present invention include:

1) accelerated denitration performance and mercury oxidation performance of catalyst and save pollutant control cost; 2) relatively high oxidation rate of zero-valent mercury under low-chlorine condition; 3) good anti-poisoning performance of catalyst and strong adaptability to severe operating conditions; 4) simple preparation process with lower cost; and thus the catalyst can be extensively applied in flue gas denitration and mercury removal in coal-fired power plants.

#### DESCRIPTION OF THE PREFERRED EMBODIMENT

Technical solution to the present invention will be further described next with specific embodiments.

Unless otherwise particularly specified, raw materials and equipment used in the present invention can be purchased from the market or are commonly used in this field, and, unless otherwise particularly specified, methods in the following examples are conventional methods in this field.

#### EXAMPLE 1

1)  $\text{TiO}_2$  (nanoscale anatase  $\text{TiO}_2$ , commercially available, particle size less than 30 nm) was dried under  $105^\circ\text{C}$ . for 12 hours and used as a carrier;

2) Ammonium metavanadate and ammonium metatungstate were stirred under  $50^\circ\text{C}$ . to dissolve in oxalic acid solution to obtain a solution A with pH value less than 2; Chromic nitrate was stirred under  $10^\circ\text{C}$ . to dissolve in deionized water to obtain a solution B; Niobium oxalate was stirred under  $50^\circ\text{C}$ . to dissolve in deionized water to obtain a solution C;

3) Cupric nitrate was stirred under  $10^\circ\text{C}$ . to dissolve in deionized water to obtain a solution D;

4) The solution A, solution B and solution C were mixed with the solution D to obtain an impregnating solution, the carrier from step 1) was immersed into the impregnating solution, stirred evenly for ultrasound concussion with ultrasonic cleaner for 10 minutes, evaporated and stirred with water bath under  $70^\circ\text{C}$ . for 10 minutes, dried in the oven under  $105^\circ\text{C}$ . for 12 hours and then calcine under  $400^\circ\text{C}$ . for 5 hours to obtain a catalyst for synergistic denitration and mercury oxidation with  $\text{V}_2\text{O}_5$ ,  $\text{WO}_3$ ,  $\text{Cr}_2\text{O}_3$ ,  $\text{Nb}_2\text{O}_5$  and  $\text{CuO}$  in the following mass percentage: carrier  $\text{TiO}_2$  98.6%, active component  $\text{V}_2\text{O}_5$  0.1%, active component  $\text{WO}_3$  1%, active component  $\text{Cr}_2\text{O}_3$  0.1%, active component  $\text{Nb}_2\text{O}_5$  0.1% and co-catalyst  $\text{CuO}$  0.1%. The prepared catalyst was grounded and sieved to obtain catalyst particles with particle size of 40-60 mesh.

Test 1:

0.2 g catalyst particle prepared in example 1 was put into a catalyst denitration activity evaluation unit and activity evaluation was conducted in a fixed bed reactor with inner diameter of 8 mm.  $\text{O}_2/\text{N}_2$ ,  $\text{NO}/\text{N}_2$ ,  $\text{NH}_3/\text{N}_2$ ,  $\text{SO}_2/\text{N}_2$  and  $\text{N}_2$  were controlled and mixed via mass flowmeter, deionized water was injected into heating pipeline for vaporization by adjusting volume in a micro-injection pump to realize addition of vapor and obtain simulated flue gas in such composition as 5%  $\text{O}_2$ , 1000 ppmNO, 1000  $\text{NH}_3$ , 500 ppm $\text{SO}_2$  and 10%  $\text{H}_2\text{O}$ , with  $\text{N}_2$  as balance gas, air speed of 300000  $\text{h}^{-1}$ ,

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reaction temperature of  $350^\circ\text{C}$ . and  $\text{NH}_3/\text{NO}$  as 1. Test gas composition with ULTRMAT 32 gas analyzer manufactured by SIEMENS and the denitration efficiency was 72%.

0.2 g catalyst particle prepared in example 1 was put into a catalyst mercury removal activity evaluation unit and activity evaluation was conducted in a fixed bed reactor with inner diameter of 8 mm.  $\text{Hg}^0/\text{N}_2$ ,  $\text{O}_2/\text{N}_2$ ,  $\text{HCl}/\text{N}_2$ ,  $\text{NO}/\text{N}_2$ ,  $\text{NH}_3/\text{N}_2$ ,  $\text{SO}_2/\text{N}_2$  and  $\text{N}_2$  were controlled and mixed via mass flowmeter, deionized water was injected into heating pipeline for vaporization by adjusting volume in a micro-injection pump to realize addition of vapor and obtain simulated flue gas in such composition as 100  $\mu\text{g}/\text{m}^3\text{Hg}^0$ , 5%  $\text{O}_2$ , 10 ppmHCl, 300 ppmNO, 50 ppm $\text{NH}_3$ , 500 ppm $\text{SO}_2$  and 10%  $\text{H}_2\text{O}$ , with  $\text{N}_2$  as balance gas, air speed of 300000 $\text{h}^{-1}$  and reaction temperature of  $350^\circ\text{C}$ . Mercury concentration was tested with EMP-2 portable mercury analyzer manufactured by NIC and the oxygenation rate of zero-valent mercury was 68%.

#### EXAMPLE 2

1)  $\text{TiO}_2$  (nanoscale anatase  $\text{TiO}_2$ , commercially available, particle size less than 30 nm) was dried under  $105^\circ\text{C}$ . for 12 hours and used as a carrier;

2) Ammonium metavanadate and ammonium metatungstate were stirred under  $50^\circ\text{C}$ . to dissolve in tartaric acid solution to obtain a solution A with pH value less than 2;

Chromic nitrate was stirred under  $10^\circ\text{C}$ . to dissolve in deionized water to obtain a solution B;

Niobium oxalate was stirred under  $50^\circ\text{C}$ . to dissolve in deionized water to obtain a solution C;

3) Cupric nitrate was stirred under  $30^\circ\text{C}$ . to dissolve in tartaric acid to obtain a solution D;

4) the solution A, solution B and solution C were mixed with the solution D to obtain an impregnating solution, the carrier from step 1) was immersed into the impregnating solution, stirred evenly for ultrasound concussion with ultrasonic cleaner for 10 minutes, evaporated and stirred with water bath under  $70^\circ\text{C}$ . for 10 minutes, dried in the oven under  $105^\circ\text{C}$ . for 12 hours and then calcined under  $400^\circ\text{C}$ . for 5 hours to obtain a catalyst for synergistic denitration and mercury oxidation with  $\text{V}_2\text{O}_5$ ,  $\text{WO}_3$ ,  $\text{Cr}_2\text{O}_3$ ,  $\text{Nb}_2\text{O}_5$  and  $\text{CuO}$  in the following mass percentage: carrier  $\text{TiO}_2$  92.4%, active component  $\text{V}_2\text{O}_5$  0.1%, active component  $\text{WO}_3$  1%, active component  $\text{Cr}_2\text{O}_3$  2.5%, active component  $\text{Nb}_2\text{O}_5$  2.5% and co-catalyst  $\text{CuO}$  1.5%. The prepared catalyst was grounded and sieved to obtain catalyst particles with particle size of 40-60 mesh.

Test 2:

0.2 g catalyst particle prepared in example 2 was put into a catalyst denitration activity evaluation unit and activity evaluation was conducted in a fixed bed reactor with inner diameter of 8 mm.  $\text{O}_2/\text{N}_2$ ,  $\text{NO}/\text{N}_2$ ,  $\text{NH}_3/\text{N}_2$ ,  $\text{SO}_2/\text{N}_2$  and  $\text{N}_2$  were controlled and mixed via mass flowmeter, deionized water was injected into heating pipeline for vaporization by adjusting volume in a micro-injection pump to realize addition of vapor and obtain simulated flue gas in such composition as 5%  $\text{O}_2$ , 1000 ppmNO, 1000 $\text{NH}_3$ , 500 ppm $\text{SO}_2$  and 10% $\text{H}_2\text{O}$ , with  $\text{N}_2$  as balance gas, air speed of 300000  $\text{h}^{-1}$ , reaction temperature of  $350^\circ\text{C}$ . and  $\text{NH}_3/\text{NO}$  as 1. Gas composition was tested with ULTRMAT 32 gas analyzer manufactured by SIEMENS and the denitration efficiency was 75%.

0.2 g catalyst particle prepared in example 2 was put into a catalyst mercury removal activity evaluation unit and activity evaluation was conducted in a fixed bed reactor with inner diameter of 8 mm.  $\text{Hg}^0/\text{N}_2$ ,  $\text{O}_2/\text{N}_2$ ,  $\text{HCl}/\text{N}_2$ ,  $\text{NO}/\text{N}_2$ ,

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NH<sub>3</sub>/N<sub>2</sub>, SO<sub>2</sub>/N<sub>2</sub> and N<sub>2</sub> were controlled and mixed via mass flowmeter, deionized water was injected into heating pipeline for vaporization by adjusting volume in a micro-injection pump to realize addition of vapor and obtain simulated flue gas in such composition as 100 μg/m<sup>3</sup>Hg<sup>0</sup>, 5%O<sub>2</sub>, 10 ppmHCl, 300 ppmNO, 50 ppmNH<sub>3</sub>, 500 ppmSO<sub>2</sub> and 10%H<sub>2</sub>O, with N<sub>2</sub> as balance gas, air speed of 300000 h<sup>-1</sup> and reaction temperature of 350° C. Mercury concentration was tested with EMP-2 portable mercury analyzer manufactured by NIC and the oxygenation rate of zero-valent mercury was 70%.

## EXAMPLE 3

1) TiO<sub>2</sub> (nanoscale anatase TiO<sub>2</sub>, commercially available, particle size less than 30 nm) was dried under 105° C. for 12 hours and used as a carrier;

2) Ammonium metavanadate and ammonium metatungstate were stirred under 50° C. to dissolve in oxalic acid solution to obtain a solution A with pH value less than 2;

Chromic nitrate was stirred under 10° C. to dissolve in deionized water to obtain a solution B;

Niobium oxalate was stirred under 50° C. to dissolve in deionized water to obtain a solution C;

3) Cupric nitrate was stirred under 50° C. to dissolve in deionized water to obtain a solution D;

4) The solution A, solution B and solution C were mixed with the solution D to obtain an impregnating solution, the carrier from step 1) was immersed into the impregnating solution, stirred evenly for ultrasound concussion with ultrasonic cleaner for 10 minutes, evaporated and stirred with water bath under 70° C. for 10 minutes, dried in the oven under 105° C. for 12 hours and then calcined under 400° C. for 5 hours to obtain a catalyst for synergistic denitration and mercury oxidation with V<sub>2</sub>O<sub>5</sub>, WO<sub>3</sub>, Cr<sub>2</sub>O<sub>3</sub>, Nb<sub>2</sub>O<sub>5</sub> and CuO in the following mass percentage: carrier TiO<sub>2</sub> 85.9%, active component V<sub>2</sub>O<sub>5</sub> 0.1%, active component WO<sub>3</sub> 1%, active component Cr<sub>2</sub>O<sub>3</sub> 5%, active component Nb<sub>2</sub>O<sub>5</sub> 5% and co-catalyst CuO 3%. The prepared catalyst was grounded and sieved to obtain catalyst particles with particle size of 40-60 mesh.

## Test 3

0.2 g catalyst particle prepared in example 3 was put into a catalyst denitration activity evaluation unit and activity evaluation was conducted in a fixed bed reactor with inner diameter of 8 mm. O<sub>2</sub>/N<sub>2</sub>, NO/N<sub>2</sub>, NH<sub>3</sub>/N<sub>2</sub>, SO<sub>2</sub>/N<sub>2</sub> and N<sub>2</sub> were controlled and mixed via mass flowmeter, deionized water was injected into heating pipeline for vaporization by adjusting volume in a micro-injection pump to realize addition of vapor and obtain simulated flue gas in such composition as 5% O<sub>2</sub>, 1000 ppmNO, 1000NH<sub>3</sub>, 500 ppmSO<sub>2</sub> and 10% H<sub>2</sub>O, with N<sub>2</sub> as balance gas, air speed of 300000 h<sup>-1</sup>, reaction temperature of 350° C. and NH<sub>3</sub>/NO as 1. Gas composition was tested with ULTRMAT 32 gas analyzer manufactured by SIEMENS and the denitration efficiency was 79%.

0.2 g catalyst particle prepared in example 3 was put into a catalyst mercury removal activity evaluation unit and activity evaluation was conducted in a fixed bed reactor with inner diameter of 8 mm. Hg<sup>0</sup>/N<sub>2</sub>, O<sub>2</sub>/N<sub>2</sub>, HCl/N<sub>2</sub>, NO/N<sub>2</sub>, NH<sub>3</sub>/N<sub>2</sub>, SO<sub>2</sub>/N<sub>2</sub> and N<sub>2</sub> were controlled and mixed via mass flowmeter, deionized water was injected into heating pipeline for vaporization by adjusting volume in a micro-injection pump to realize addition of vapor and obtain simulated flue gas in such composition as 100 μg/m<sup>3</sup>Hg<sup>0</sup>, 5% O<sub>2</sub>, 10 ppmHCl, 300 ppmNO, 50 ppmNH<sub>3</sub>, 500 ppmSO<sub>2</sub> and 10% H<sub>2</sub>O, with N<sub>2</sub> as balance gas, air speed of 300000

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h<sup>-1</sup> and reaction temperature of 350° C. Mercury concentration was tested with EMP-2 portable mercury analyzer manufactured by NIC and the oxygenation rate of zero-valent mercury was 73%.

## EXAMPLE 4

1) TiO<sub>2</sub> (nanoscale anatase TiO<sub>2</sub>, commercially available, particle size less than 30 nm) was tried under 110° C. for 18 hours and used as a carrier;

2) Ammonium metavanadate and ammonium metatungstate were stirred under 60° C. to dissolve in oxalic acid solution to obtain a solution A with pH value less than 2;

Chromic nitrate was stirred under 30° C. to dissolve in deionized water to obtain a solution B;

Niobium oxalate was stirred under 60° C. to dissolve in deionized water to obtain a solution C;

3) Ferric nitrate was stirred under 10° C. to dissolve in deionized water to obtain a solution E;

4) The solution A, solution B and solution C were mixed with the solution E to obtain an impregnating solution, the carrier from step 1) was immersed into the impregnating solution, stirred evenly for ultrasound concussion with ultrasonic cleaner for 30 minutes, evaporated and stirred with water bath under 80° C. for 30 minutes, dried in the oven under 110° C. for 18 hours and then calcined under 475° C. for 4 hours to obtain a catalyst for synergistic denitration and mercury oxidation with V<sub>2</sub>O<sub>5</sub>, WO<sub>3</sub>, Cr<sub>2</sub>O<sub>3</sub>, Nb<sub>2</sub>O<sub>5</sub> and Fe<sub>2</sub>O<sub>3</sub> in the following mass percentage:

carrier TiO<sub>2</sub> 92.2%, active component V<sub>2</sub>O<sub>5</sub> 2.5%, active component WO<sub>3</sub> 5%, active component Cr<sub>2</sub>O<sub>3</sub> 0.1%, active component Nb<sub>2</sub>O<sub>5</sub> 0.1% and co-catalyst Fe<sub>2</sub>O<sub>3</sub> 0.1%. The prepared catalyst was grounded and sieved to obtain catalyst particles with particle size of 40-60 mesh.

## Test 4

0.2 g catalyst particle prepared in example 4 was put into a catalyst denitration activity evaluation unit and activity evaluation was conducted in a fixed bed reactor with inner diameter of 8 mm. O<sub>2</sub>/N<sub>2</sub>, NO/N<sub>2</sub>, NH<sub>3</sub>/N<sub>2</sub>, SO<sub>2</sub>/N<sub>2</sub> and N<sub>2</sub> were controlled and mixed via mass flowmeter, deionized water was injected into heating pipeline for vaporization by adjusting volume in a micro-injection pump to realize addition of vapor and obtain simulated flue gas in such composition as 5% O<sub>2</sub>, 1000 ppmNO, 1000 NH<sub>3</sub>, 500 ppmSO<sub>2</sub> and 10%H<sub>2</sub>O, with N<sub>2</sub> as balance gas, air speed of 300000 h<sup>-1</sup>, reaction temperature of 350° C. and NH<sub>3</sub>/NO as 1. Gas composition was tested with ULTRMAT 32 gas analyzer manufactured by SIEMENS and the denitration efficiency was 83%.

0.2 g catalyst particle prepared in example 4 was put into a catalyst mercury removal activity evaluation unit and activity evaluation was conducted in a fixed bed reactor with inner diameter of 8 mm. Hg<sup>0</sup>/N<sub>2</sub>, O<sub>2</sub>/N<sub>2</sub>, HCl/N<sub>2</sub>, NO/N<sub>2</sub>, NH<sub>3</sub>/N<sub>2</sub>, SO<sub>2</sub>/N<sub>2</sub> and N<sub>2</sub> was controlled and mixed via mass flowmeter, deionized water was injected into heating pipeline for vaporization by adjusting volume in a micro-injection pump to realize addition of vapor and obtain simulated flue gas in such composition as 100 μg/m<sup>3</sup>Hg<sup>0</sup>, 5% O<sub>2</sub>, 10 ppmHCl, 300 ppmNO, 50 ppmNH<sub>3</sub>, 500 ppmSO<sub>2</sub> and 10% H<sub>2</sub>O, with N<sub>2</sub> as balance gas, air speed of 300000 h<sup>-1</sup> and reaction temperature of 350° C. Mercury concentration was tested with EMP-2 portable mercury analyzer manufactured by NIC and the oxygenation rate of zero-valent mercury was 79%.

## EXAMPLE 5

1) TiO<sub>2</sub> (nanoscale anatase TiO<sub>2</sub>, commercially available, particle size less than 30 nm) was dried under 110° C. for 18 hours and used as a carrier;

2) Ammonium metavanadate and ammonium metatungstate were stirred under 60° C. to dissolve in tartaric acid solution to obtain a solution A with pH value less than 2;

Chromic nitrate was stirred under 30° C. to dissolve in deionized water to obtain a solution B;

Niobium oxalate was stirred under 60° C. to dissolve in deionized water to obtain a solution C;

3) Ferric nitrate was stirred under 30° C. to dissolve in tartaric acid to obtain a solution E;

4) The solution A, solution B and solution C were mixed with the solution E to obtain an impregnating solution, the carrier from step 1) was immersed into the impregnating solution, stirred evenly for ultrasound concussion with an ultrasonic cleaner for 30 minutes, evaporated and stirred with water bath under 80° C. for 30 minutes, dried in the oven under 110° C. for 18 hours and then calcined under 475° C. for 4 hours to obtain a catalyst for synergistic denitration and mercury oxidation with V<sub>2</sub>O<sub>5</sub>, WO<sub>3</sub>, Cr<sub>2</sub>O<sub>3</sub>, Nb<sub>2</sub>O<sub>5</sub> and Fe<sub>2</sub>O<sub>3</sub> in the following mass percentage: carrier TiO<sub>2</sub> 86%, active component V<sub>2</sub>O<sub>5</sub> 2.5%, active component WO<sub>3</sub> 5%, active component Cr<sub>2</sub>O<sub>3</sub> 2.5%, active component Nb<sub>2</sub>O<sub>5</sub> 2.5% and co-catalyst Fe<sub>2</sub>O<sub>3</sub> 1.5%. The prepared catalyst was grounded and sieved to obtain catalyst particles with particle size of 40-60 mesh.

#### Test 5

0.2 g catalyst particle prepared in example 5 was put into a catalyst denitration activity evaluation unit and activity evaluation was conducted in a fixed bed reactor with an inner diameter of 8 mm. O<sub>2</sub>/N<sub>2</sub>, NO/N<sub>2</sub>, NH<sub>3</sub>/N<sub>2</sub>, SO<sub>2</sub>/N<sub>2</sub> and N<sub>2</sub> were controlled and mixed via mass flowmeter, deionized water was injected into heating pipeline for vaporization by adjusting volume in a micro-injection pump to realize addition of vapor and obtain simulated flue gas in such composition as 5% O<sub>2</sub>, 1000 ppmNO, 1000NH<sub>3</sub>, 500 ppmSO<sub>2</sub> and 10% H<sub>2</sub>O, with N<sub>2</sub> as balance gas, air speed of 300000 h<sup>-1</sup>, reaction temperature of 350° C. and NH<sub>3</sub>/NO as 1. Gas composition was tested with ULTRMAT 32 gas analyzer manufactured by SIEMENS and the denitration efficiency was 86%.

0.2 g catalyst particle prepared in example 5 was put into a catalyst mercury removal activity evaluation unit and activity evaluation was conducted in a fixed bed reactor with an inner diameter of 8 mm. Hg<sup>0</sup>/N<sub>2</sub>, O<sub>2</sub>/N<sub>2</sub>, HCl/N<sub>2</sub>, NO/N<sub>2</sub>, NH<sub>3</sub>/N<sub>2</sub>, SO<sub>2</sub>/N<sub>2</sub> and N<sub>2</sub> were controlled and mixed via mass flowmeter, deionized water was injected into heating pipeline for vaporization by adjusting volume in a micro-injection pump to realize addition of vapor and obtain simulated flue gas in such composition as 100 µg/m<sup>3</sup>Hg<sup>0</sup>, 5% O<sub>2</sub>, 10 ppmHCl, 300 ppmNO, 50 ppmNH<sub>3</sub>, 500 ppmSO<sub>2</sub> and 10% H<sub>2</sub>O, with N<sub>2</sub> as balance gas, air speed of 300000 h<sup>-1</sup> and reaction temperature of 350° C. Mercury concentration was tested with EMP-2 portable mercury analyzer manufactured by NIC and the oxygenation rate of zero-valent mercury was 84%.

#### EXAMPLE 6

1) TiO<sub>2</sub> (nanoscale anatase TiO<sub>2</sub>, commercially available, particle size less than 30 nm) was dried under 110° C. for 18 hours and used as a carrier;

2) Ammonium metavanadate and ammonium metatungstate were stirred under 60° C. to dissolve in oxalic acid solution to obtain a solution A with pH value less than 2;

Chromic nitrate was stirred under 30° C. to dissolve in deionized water to obtain a solution B;

Niobium oxalate was stirred under 60° C. to dissolve in deionized water to obtain a solution C;

3) Ferric nitrate was stirred under 50° C. to dissolve in deionized water to obtain a solution E;

4) The solution A, solution B and solution C were mixed with the solution E to obtain an impregnating solution, the carrier from step 1) was immersed into the impregnating solution, stirred evenly for ultrasound concussion with ultrasonic cleaner for 30 minutes, evaporated and stirred with water bath under 80° C. for 30 minutes, dried in the oven under 110° C. for 18 hours and then calcined under 475° C. for 4 hours to obtain a catalyst for synergistic denitration and mercury oxidation with V<sub>2</sub>O<sub>5</sub>, WO<sub>3</sub>, Cr<sub>2</sub>O<sub>3</sub>, Nb<sub>2</sub>O<sub>5</sub> and Fe<sub>2</sub>O<sub>3</sub> in the following mass percentage: carrier TiO<sub>2</sub> 79.5%, active component V<sub>2</sub>O<sub>5</sub> 2.5%, active component WO<sub>3</sub> 5%, active component Cr<sub>2</sub>O<sub>3</sub> 5%, active component Nb<sub>2</sub>O<sub>5</sub> 5% and co-catalyst Fe<sub>2</sub>O<sub>3</sub> 3%. The prepared catalyst was grounded and sieved to obtain catalyst particles with particle size of 40-60 mesh.

#### Test 6

0.2 g catalyst particle prepared in example 6 was put into a catalyst denitration activity evaluation unit and activity evaluation was conducted in a fixed bed reactor with inner diameter of 8 mm. O<sub>2</sub>/N<sub>2</sub>, NO/N<sub>2</sub>, NH<sub>3</sub>/N<sub>2</sub>, SO<sub>2</sub>/N<sub>2</sub> and N<sub>2</sub> were controlled and mixed via mass flowmeter, deionized water was injected into heating pipeline for vaporization by adjusting volume in a micro-injection pump to realize addition of vapor and obtain simulated flue gas in such composition as 5% O<sub>2</sub>, 1000 ppmNO, 1000 NH<sub>3</sub>, 500 ppmSO<sub>2</sub> and 10% H<sub>2</sub>O, with N<sub>2</sub> as balance gas, air speed of 300000 h<sup>-1</sup>, reaction temperature of 350° C. and NH<sub>3</sub>/NO as 1. Gas composition was tested with ULTRMAT 32 gas analyzer manufactured by SIEMENS and the denitration efficiency was 88%.

0.2 g catalyst particle prepared in example 6 was put into a catalyst mercury removal activity evaluation unit and activity evaluation was conducted in a fixed bed reactor with inner diameter of 8 mm. Hg<sup>0</sup>/N<sub>2</sub>, O<sub>2</sub>/N<sub>2</sub>, HCl/N<sub>2</sub>, NO/N<sub>2</sub>, NH<sub>3</sub>/N<sub>2</sub>, SO<sub>2</sub>/N<sub>2</sub> and N<sub>2</sub> were controlled and mixed via mass flowmeter, deionized water was injected into a heating pipeline for vaporization by adjusting volume in a micro-injection pump to realize addition of vapor and obtain simulated flue gas in such composition as 100 µg/m<sup>3</sup>Hg<sup>0</sup>, 5% O<sub>2</sub>, 10 ppmHCl, 300 ppmNO, 50 ppmNH<sub>3</sub>, 500 ppmSO<sub>2</sub> and 10% H<sub>2</sub>O, with N<sub>2</sub> as balance gas, air speed of 300000 h<sup>-1</sup> and reaction temperature of 350° C. Mercury concentration was tested with EMP-2 portable mercury analyzer manufactured by NIC and the oxygenation rate of zero-valent mercury was 87%.

#### EXAMPLE 7

1) TiO<sub>2</sub> (nanoscale anatase TiO<sub>2</sub>, commercially available, particle size less than 30 nm) was dried under 120° C. for 24 hours and used as a carrier;

2) Ammonium metavanadate and ammonium metatungstate were stirred under 70° C. to dissolve in oxalic acid solution to obtain a solution A with pH value less than 2;

Chromic nitrate was stirred under 50° C. to dissolve in deionized water to obtain a solution B;

Niobium oxalate was stirred under 70° C. to dissolve in deionized water to obtain a solution C;

3) Ammonium molybdate was stirred under 10° C. to dissolve in deionized water to obtain a solution F;

4) The solution A, solution B and solution C were mixed with the solution F to obtain an impregnating solution, the carrier from step 1) was immersed into the impregnating solution, stirred evenly for ultrasound concussion with ultrasonic cleaner for 60 minutes, evaporated and stirred with

water bath under 90° C. for 60 minutes, dried in the oven under 120° C. for 24 hours and then calcined under 550° C. for 3 hours to obtain a catalyst for synergistic denitration and mercury oxidation with V<sub>2</sub>O<sub>5</sub>, WO<sub>3</sub>, Cr<sub>2</sub>O<sub>3</sub>, Nb<sub>2</sub>O<sub>5</sub> and MoO<sub>3</sub> in the following mass percentage: carrier TiO<sub>2</sub> 84.7%, active component V<sub>2</sub>O<sub>5</sub> 5%, active component WO<sub>3</sub> 10%, active component Cr<sub>2</sub>O<sub>3</sub> 0.1%, active component Nb<sub>2</sub>O<sub>5</sub> 0.1% and co-catalyst MoO<sub>3</sub> 0.1%. The prepared catalyst was grounded and sieved to obtain catalyst particles with particle size of 40-60 mesh.

#### Test 7

0.2 g catalyst particle prepared in example 7 was put into a catalyst denitration activity evaluation unit and activity evaluation was conducted in a fixed bed reactor with inner diameter of 8 mm. O<sub>2</sub>/N<sub>2</sub>, NO/N<sub>2</sub>, NH<sub>3</sub>/N<sub>2</sub>, SO<sub>2</sub>/N<sub>2</sub> and N<sub>2</sub> via mass flowmeter were controlled and mixed, deionized water was injected into heating pipeline for vaporization by adjusting volume in a micro-injection pump to realize addition of vapor and obtain simulated flue gas in such composition as 5% O<sub>2</sub>, 1000 ppmNO, 1000NH<sub>3</sub>, 500 ppmSO<sub>2</sub> and 10% H<sub>2</sub>O, with N<sub>2</sub> as balance gas, air speed of 300000 h<sup>-1</sup>, reaction temperature of 350° C. and NH<sub>3</sub>/NO as 1. Gas composition was tested with ULTRMAT 32 gas analyzer manufactured by SIEMENS and the denitration efficiency was 90%.

0.2 g catalyst particle prepared in example 7 was into a catalyst mercury removal activity evaluation unit and activity evaluation was conducted in a fixed bed reactor with inner diameter of 8 mm. Hg<sup>0</sup>/N<sub>2</sub>, O<sub>2</sub>/N<sub>2</sub>, HCl/N<sub>2</sub>, NO/N<sub>2</sub>, NH<sub>3</sub>/N<sub>2</sub>, SO<sub>2</sub>/N<sub>2</sub> and N<sub>2</sub> were controlled and mixed via mass flowmeter, deionized water was injected into heating pipeline for vaporization by adjusting volume in a micro-injection pump to realize addition of vapor and obtain simulated flue gas in such composition as 100 µg/m<sup>3</sup>Hg<sup>0</sup>, 5% O<sub>2</sub>, 10 ppmHCl, 300 ppmNO, 50 ppmNH<sub>3</sub>, 500 ppmSO<sub>2</sub> and 10% H<sub>2</sub>O, with N<sub>2</sub> as balance gas, air speed of 300000 h<sup>-1</sup> and reaction temperature of 350° C.

Mercury concentration was tested with EMP-2 portable mercury analyzer manufactured by NIC and the oxygenation rate of zero-valent mercury was 89%.

#### EXAMPLE 8

1) TiO<sub>2</sub> (nanoscale anatase TiO<sub>2</sub>, commercially available, particle size less than 30 nm) was dried under 120° C. for 24 hours and used as a carrier;

2) Ammonium metavanadate and ammonium metatungstate were stirred under 70° C. to dissolve in tartaric acid solution to obtain a solution A with pH value less than 2;

Chromic nitrate was stirred under 50° C. to dissolve in deionized water to obtain a solution B;

Niobium oxalate was stirred under 70° C. to dissolve in deionized water to obtain a solution C;

3) Ammonium molybdate was stirred under 30° C. to dissolve in tartaric acid to obtain a solution F;

4) The solution A, solution B and solution C with the solution F were mixed to obtain an impregnating solution, the carrier from step 1) was immersed into the impregnating solution, stirred evenly for ultrasound concussion with ultrasonic cleaner for 60 minutes, evaporated and stirred with water bath under 90° C. for 60 minutes, dried in the oven under 120° C. for 24 hours and then calcined under 550° C. for 3 hours to obtain a catalyst for synergistic denitration and mercury oxidation with V<sub>2</sub>O<sub>5</sub>, WO<sub>3</sub>, Cr<sub>2</sub>O<sub>3</sub>, Nb<sub>2</sub>O<sub>5</sub> and MoO<sub>3</sub> in the following mass percentage: carrier TiO<sub>2</sub> 78.5%, active component V<sub>2</sub>O<sub>5</sub> 5%, active component WO<sub>3</sub> 10%, active component Cr<sub>2</sub>O<sub>3</sub> 2.5%, active component Nb<sub>2</sub>O<sub>5</sub>

2.5% and co-catalyst MoO<sub>3</sub> 1.5%. The prepared catalyst was grounded and sieved to obtain catalyst particles with particle size of 40-60 mesh.

#### Test 8

0.2 g catalyst particle prepared in example 8 was put into a catalyst denitration activity evaluation unit and activity evaluation was conducted in a fixed bed reactor with an inner diameter of 8 mm. O<sub>2</sub>/N<sub>2</sub>, NO/N<sub>2</sub>, NH<sub>3</sub>/N<sub>2</sub>, SO<sub>2</sub>/N<sub>2</sub> and N<sub>2</sub> were controlled and mixed via mass flowmeter, deionized water was injected into heating pipeline for vaporization by adjusting volume in a micro-injection pump to realize addition of vapor and obtain simulated flue gas in such composition as 5% O<sub>2</sub>, 1000 ppmNO, 1000NH<sub>3</sub>, 500 ppmSO<sub>2</sub> and 10% H<sub>2</sub>O, with N<sub>2</sub> as balance gas, air speed of 300000 h<sup>-1</sup>, reaction temperature of 350° C. and NH<sub>3</sub>/NO as 1. Gas composition was tested with ULTRMAT 32 gas analyzer manufactured by SIEMENS and the denitration efficiency was 94%.

0.2 g catalyst particle prepared in example 8 was put into a catalyst mercury removal activity evaluation unit and activity evaluation was conducted in a fixed bed reactor with inner diameter of 8 mm. Hg<sup>0</sup>/N<sub>2</sub>, O<sub>2</sub>/N<sub>2</sub>, HCl/N<sub>2</sub>, NO/N<sub>2</sub>, NH<sub>3</sub>/N<sub>2</sub>, SO<sub>2</sub>/N<sub>2</sub> and N<sub>2</sub> via mass flowmeter were controlled and mixed, deionized water was injected into a heating pipeline for vaporization by adjusting volume in a micro-injection pump to realize addition of vapor and obtain simulated flue gas in such composition as 100 µg/m<sup>3</sup>Hg<sup>0</sup>, 5% O<sub>2</sub>, 10 ppmHCl, 300 ppmNO, 50 ppmNH<sub>3</sub>, 500 ppmSO<sub>2</sub> and 10% H<sub>2</sub>O, with N<sub>2</sub> as balance gas, air speed of 300000 h<sup>-1</sup> and reaction temperature of 350° C. Mercury concentration was tested with EMP-2 portable mercury analyzer manufactured by NIC and the oxygenation rate of zero-valent mercury was 91%.

#### EXAMPLE 9

1) TiO<sub>2</sub> (nanoscale anatase TiO<sub>2</sub>, commercially available, particle size less than 30 nm) was dried under 120° C. for 24 hours and used as a carrier;

2) Ammonium metavanadate and ammonium metatungstate were dried under 70° C. to dissolve in oxalic acid solution to obtain a solution A with pH value less than 2;

Chromic nitrate was stirred under 50° C. to dissolve in deionized water to obtain a solution B;

Niobium oxalate was stirred under 70° C. to dissolve in deionized water to obtain a solution C;

3) Ammonium molybdate was stirred under 50° C. to dissolve in deionized water to obtain a solution F;

4) The solution A, solution B and solution C were mixed with the solution F to obtain an impregnating solution, the carrier from step 1) was immersed into the impregnating solution, stirred evenly for ultrasound concussion with ultrasonic cleaner for 60 minutes, evaporated and stirred with water bath under 90° C. for 60 minutes, dried in the oven under 120° C. for 24 hours and then calcined under 550° C. for 3 hours to obtain a catalyst for synergistic denitration and mercury oxidation with V<sub>2</sub>O<sub>5</sub>, WO<sub>3</sub>, Cr<sub>2</sub>O<sub>3</sub>, Nb<sub>2</sub>O<sub>5</sub> and MoO<sub>3</sub> in the following mass percentage: carrier TiO<sub>2</sub> 72%, active component V<sub>2</sub>O<sub>5</sub> 5%, active component WO<sub>3</sub> 10%, active component Cr<sub>2</sub>O<sub>3</sub> 5%, active component Nb<sub>2</sub>O<sub>5</sub> 5% and co-catalyst MoO<sub>3</sub> 3%. The prepared catalyst was grounded and sieved to obtain catalyst particles with particle size of 40-60 mesh.

#### Test 9

0.2 g catalyst particle prepared in example 9 was put into a catalyst denitration activity evaluation unit and activity evaluation was conducted in a fixed bed reactor with inner

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diameter of 8 mm.  $O_2/N_2$ ,  $NO/N_2$ ,  $NH_3/N_2$ ,  $SO_2/N_2$  and  $N_2$  via mass flowmeter were controlled and mixed, deionized water was injected into heating pipeline for vaporization by adjusting volume in a micro-injection pump to realize addition of vapor and obtain simulated flue gas in such composition as 5%  $O_2$ , 1000 ppmNO, 1000ppm $NH_3$ , 500 ppm $SO_2$  and 10%  $H_2O$ , with  $N_2$  as balance gas, air speed of 300000  $h^{-1}$ , reaction temperature of 350° C. and  $NH_3/NO$  as 1. Gas composition was tested with ULTRMAT 32 gas analyzer manufactured by SIEMENS and the denitration efficiency was 96%.

0.2 g catalyst particle prepared in example 9 was put into a catalyst mercury removal activity evaluation unit and activity evaluation was conducted in a fixed bed reactor with an inner diameter of 8 mm.  $Hg^0/N_2$ ,  $O_2/N_2$ ,  $HCl/N_2$ ,  $NO/N_2$ ,  $NH_3/N_2$ ,  $SO_2/N_2$  and  $N_2$  were controlled and mixed via mass flowmeter, deionized water was injected into heating pipeline for vaporization by adjusting volume in a micro-injection pump to realize addition of vapor and obtain simulated flue gas in such composition as 100  $\mu g/m^3 Hg^0$ , 5%  $O_2$ , 10 ppmHCl, 300 ppmNO, 50 ppm $NH_3$ , 500 ppm $SO_2$  and 10%  $H_2O$ , with  $N_2$  as balance gas, air speed of 300000  $h^{-1}$  and reaction temperature of 350° C. Mercury concentration was tested with EMP-2 portable mercury analyzer manufactured by NIC and the oxygenation rate of zero-valent mercury was 95%.

The aforesaid example is just a better scheme for the present invention, instead of any form of limitation, and other variants and versions are allowed on the premise of not exceeding the technical solution recorded in the claims.

The invention claimed is:

1. A method for preparing a catalyst for synergistic control of oxynitride and mercury, wherein the method comprises the following steps:

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- 1) drying  $TiO_2$  and use  $TiO_2$  as a carrier;
- 2) stirring ammonium metavanadate and ammonium metatungstate under 50° C.-70° C. to dissolve in an oxalic acid or tartaric acid solution to obtain a solution A with pH value less than 2; stirring chromic nitrate under 10-50° C. to dissolve in deionized water or tartaric acid to obtain a solution B; stirring niobium oxalate under 50-70° C. to dissolve in deionized water or tartaric acid to obtain a solution C;
- 3) stirring cupric nitrate under 10-50° C. to dissolve in deionized water or tartaric acid to obtain a solution D; or stirring ferric nitrate under 10-50° C. to dissolve in deionized water or tartaric acid to obtain a solution E; or stirring ammonium molybdate under 10-50° C. to dissolve in deionized water or tartaric acid to obtain a solution F;
- 4) mixing the solution A, solution B and solution C with one of the solution D, solution E and solution F to obtain an impregnating solution, immersing the carrier from step 1) into the impregnating solution, stirring evenly for ultrasound concussion, evaporating and stirring with water bath for 10-60 minutes, drying in the oven and then calcine under 400° C.-550° C. for 3-5 hours to obtain the catalyst for synergistic control of oxynitride and mercury.
2. The preparation method according to claim 1, wherein the drying in step 1) is drying under 105° C.-120° C. for 12 hours-24 hours.
3. The preparation method according to claim 1, wherein the ultrasound concussion time in step 4) is 10-60 minutes.
4. The preparation method according to claim 1, wherein the water bath temperature in step 4) is 70-90° C.
5. The preparation method according to claim 4, wherein the drying condition in oven in step 4) is drying under 105-120° C. for 12-24 hours.

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